

62p

SPACE SCIENCES LABORATORY

UNPUBLISHED PRELIMINARY DATA

GPO PRICE \$ _____

OTS PRICE(S) \$ _____

Hard copy (HC) 2.00

Microfiche (MF) .75

N 65 16475

(ACCESSION NUMBER)

62
(PAGES)

CR 53542
(NASA CR OR TMX CR AD NUMBER)

(THRU)

1

(CODE)

30

(CATEGORY)

FACILITY FORM 642

0519751

for period ending February 1, 1964

g-lat Series

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(January 24, 1964

TABLE OF CONTENTS

Foreword	i
Personnel	ii
Project Titles and Investigators, Contract/Grant Identification	v
Technical Reports and Papers in this Period	vii
"Solar Radiation and Atmospheric Absorption in the MM Wave Region"	1
"Radioastronomy and Upper Atmosphere Studies in the Microwave Region".	3
"General Support Grant"	5
"Contributions to Surface Magnetic Fields from Sources Internal and External to the Earth".	17
"Secular Change and the Origin of the Dipole Field"	18
"The Effect of the Ionosphere on Attenuation of 'Pearl' Activity"	19
"Detonation Studies of Mixtures of Gaseous Hydrogen and Gaseous Oxygen".	20
"Reaction Kinetics of Accelerating Flames"	21
"Development and Stabilization of Detonation"	21
✓ "Detection and Study of Microorganisms in the Upper Atmosphere"	23
"Dynamic Behavior of Porous Electrode Systems"	27
"Effects of Varied Degrees of Sensory Deprivation on Brain Chemistry, Brain Anatomy and Behavior".	28
"Facilities".	29
"Infrared Planetary Observatory in the Stratosphere"	30
✓ "Preparation of Flight Hardware for the First Interplanetary Monitor Satellite"	31
"Preparation of Flight Hardware for the First Orbiting Geophysical Observatory".	34
"Electron Precipitation into the Auroral Zone"	35
✓ "Reflection Spectra as a Basis for Studying Extraterrestrial Life"	36
"Theoretical and Experimental Evaluation of Inelastic Neutron Scattering and Other Neutron Induced Reactions for Remote Surface Analysis"	39
✓ "Biochemical Activities of Terrestrial Microorganisms in Simulated Planetary Environments"	40
"Control and Information Systems"	43
† "Space Biophysics"	48
✓ "Space Physiology"	48
"Chemistry of Living Systems"	50
"Fluid Mechanics, Thermodynamics and Heat Transfer"	52

FOREWORD

This is the fourth of the consolidated quarterly reports on all of the current research projects administered by the Space Sciences Laboratory. This form of report has been adopted in response to President Kerr's request for periodic information on the N.A.S.A. supported programs at the University of California.

It is hoped that the coverage of O.N.R., N.S.F., C.G.S., and A.F.O.S.R. as well as N.A.S.A. projects will service to enlighten both the laboratory members and the various associated academic departments of the overall operation of the laboratory and its present research activities.

In order to give a comprehensive picture of the work conducted by Prof. A. Oppenheim, his report includes projects which are administered by the Institute of Engineering Research of the College of Engineering as well as those administered by the Space Sciences Laboratory.

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PROJECT TITLES AND INVESTIGATORS
AND CONTRACT/GRANT IDENTIFICATION

<u>Faculty Investigator</u> <u>(Project Director)</u>	<u>Project Title</u>	<u>Sponsor and</u> <u>Contract/Grant No.</u>
Prof. S. Silver and J. Welch	"Solar Radiation and Atmospheric Absorption in the MM Wave Region"	ONR Contract Nonr 222(54)
Profs. S. Silver and J. Welch	"Radioastronomy and Upper Atmosphere Studies in the Micro- wave Region"	NSF Grant NSF G 16741
Prof. S. Silver Profs. C. W. Churchman and L. Preston (Social Studies)	"General Support"	NASA Grant NsG 243-62
Prof. S. Ward	"Contributions to Surface Magnetic Fields from Sources Internal and External to the Earth"	ONR Contract Nonr 222(89)
Prof. S. Ward	"Secular Change and Origin of the Dipole Field"	CGS Grant CGS 1167(G)
Profs. S. Ward and S. Silver	"Effect of the Ionosphere on Attenuation of 'Pearl' Activity"	NSF Grant NSF G P-1775
Prof. A. Oppenheim	"Detonation Studies of Mixtures of Gaseous Hydrogen and Gaseous Oxygen"	NASA Contract NAS 8-2634
Prof. A. Oppenheim	"Reaction Kinetics of Accelerating Flames"	NASA Grant NsG 10-59(1ER)
Prof. A. Oppenheim	"Development and Stabilization of Detonation"	AFOSR Grant AF 129-63(1ER)
Prof. W. Oswald	"Detection and Study of Micro- organisms in the Upper Atmosphere"	NASA Grant NsG 104-61
Prof. C. Tobias	"Dynamic Behavior of Porous Electrode Systems"	NASA Grant NsG 150-61
Profs. D. Krech and M. Rosenzweig	"Effects of Varied Degrees of Sensory Deprivation on Brain Chemistry, Brain Anatomy and Behavior"	NASA Grant NsG 154-61
Prof. S. Silver	"Facilities"	NASA Grant NsG(F)-5
Prof. H. Weaver	"Infrared Planetary Observatory in the Stratosphere"	NASA Grant NsG 255-62

PROJECT TITLES AND INVESTIGATORS (Cont.)

<u>Faculty Investigator (Project Director)</u>	<u>Project Title</u>	<u>Sponsor and Contract/Grant No.</u>
Prof. K. Anderson	"Preparation of Flight Hardware For the First Interplanetary Monitor Satellite"	NASA Contract NAS 5-2989
Prof. K. Anderson	"Preparation of Flight Hardware For the First Orbiting Geophysical Observatory"	NASA Contract NAS 5-2222
Prof. K. Anderson	"Electron Precipitation into the Auroral Zone"	NSF Grant NSF GP-2252
Profs. Calvin and Weaver (Dr. D. Rea)	"Reflection Spectra as a Basis for Studying Extraterrestrial Life"	NASA Grant NsG 101-61
Prof. H. Mark	"Theoretical and Experimental Evalu- ation of Inelastic Neutron Scattering and Other Neutron Induced Reactions for Remote Surface Analysis"	NASA Grant NsG 452
Prof. S. Silver (Dr. S. Scher)	"Biochemical Activities of Terrestrial Microorganisms in Simulated Planetary Environments"	NASA Grant NsG 126-61
Profs. Desoer, Thomasian, and Zadeh	"Control and Information Systems"	NASA Grant NsG 354
Prof. H. Jones (Dr. T. Jukes)	"Space Biophysics: Preparatory Pro- gram for Bio-satellite Research"	NASA Grant NsG 139-61
Prof. H. Jones (Dr. T. Jukes)	"Space Physiology"	NASA Contract NAS 2-1357
Prof. H. Jones (Dr. T. Jukes)	"Chemistry of Living Systems"	NASA Grant NsG 479
Prof. G. Maslach	"Fluid Mechanics, Thermodynamics, and Heat Transfer"	NSF Grant NSF GP-2103

TECHNICAL REPORTS AND PAPERS IN THIS PERIOD

NsG 243-62

"On Observations of Lunar Magnetic Storms", A Palm and S. Silver, Series 5, Issue 3. Submitted for publication in Planetary and Space Science.

NsG 101-61

"The Reflection and Emission of Electromagnetic Radiation by Planetary Surfaces and Clouds", by D. G. Rea and W. J. Welch, Space Science Reviews.

"The Darkening Wave on Mars", D. G. Rea. Submitted for publication in Nature..

NSF G 16741

"The Reflection and Emission of Electromagnetic Radiation by Planetary Surfaces and Clouds", D. G. Rea and W. J. Welch, Space Science Reviews.

"8.35 mm Radio Emission from Jupiter", D. D. Thornton and W. J. Welch. Icarus 2, 3, October 1963.

Nonr 222(54)

"8.35 mm Radio Emission from Jupiter", D. D. Thornton and W. J. Welch, Icarus 2, 3, October 1963.

NAS 8-2634

"Design of Primacord Ignition System", Laderman, Struck, Urtiew. Series 4, Issue 77.

Nonr 222(89)

"Coherency of Geoelectromagnetic Signals", S. H. Ward and H. Fournier. Series 4, Issue 72.

"Magnetotelluric Evidence for the Low Velocity Layer", H. Fournier, S. H. Ward and H. F. Morrison, Series 4, Issue 76.

"Some Remarks a Propos of Presently Known Magneto-Telluric Investigations and Sounding Curves", H. Fournier, translation by H. Fournier and S. H. Ward. Series 4, Issue 79.

"On a Very Particular Case of the Directional Distribution of Apparent Resistivity Values given by Magnetotelluric Soundings with 20 Second Periods", by H. Fournier, translation by H. Fournier and F. Morrison. Series 4, Issue 80.

TECHNICAL REPORTS AND PAPERS IN THIS PERIOD (Cont.)

Nonr 222(89) (Cont.)

- "Directional Magnetotelluric Spectra at Garchy, Nivre", by H. Fournier, translation by H. Fournier and S. H. Ward. Series 4, Issue 81.
- "Digital Filtering of Geoelectromagnetic Disturbances", by D. P. O'Brien and S. H. Ward, Series 4, Issue 83.
- "Relations between the Electric and Magnetic Fields of a Wave of Very Long Period Induced in a Medium of Variable Conductivity", by L. Bossy and A. DeVuyst, translation by H. F. Morrison and S. H. Ward, Series 4, Issue 84.
- "The State of Magneto-tellurics in the Soviet Union", by Gottsfried Porstendorfer, translation by Paul Baltenberger and Hugo Fournier (German to French), and H. F. Morrison (French to English). Series 4, Issue 85.
- "Geomagnetic Bays - A Review", by Ruben Zelwer, Series 4, Issue 86.

"SOLAR RADIATION AND ATMOSPHERIC
ABSORPTION IN THE MM WAVE REGION"

ONR Contract
Nonr 222(54)

Installation of the 10-foot Telescope at Hat Creek

The principal machine work on the mount has been completed. The mount is assembled in Berkeley. It will be taken to the Hat Creek site for installation within the next two months. There has been a slight delay in replacing one of the hydraulic pulse motors which was damaged in shipment.

Instrumentation for Ozone Studies

Work is continuing on the development of a radiometer to investigate the Ozone absorption in the 36 kmc region. Efforts during the past quarter have been concentrated on the development of a power supply whose output can be switched between two constant levels at a 33 cps rate. This supply would then be used to switch the Backward Wave Oscillator which serves as local oscillator between two frequencies at 33 cps. Several versions of such a supply have been constructed; however, the voltage stability and a. c. ripple have not been reduced to an acceptable level as yet. There are no fundamental problems involved and each version has been a distinct improvement over the last.

Just now a two frequency switching radiometer is being assembled which utilizes two klystrons rather than the backward wave oscillator. All the components required have been constructed, and their integration into a radiometer is now in progress. This radiometer will be used to evaluate the proposed techniques for investigating the Ozone lines and to obtain an experimental value for the magnitude of the lines. This magnitude would then be compared with the theoretical value previously calculated.

8 mm Maser Development - Design and Construction

Most efforts in the last quarter were devoted to the fabrication of the Maser components. Due to the extremely small size (.4mm x .4mm) of the crystal and conducting enclosure, great difficulty is experienced. The conducting enclosure is being made by electroforming. It has not been

successful so far. Fabrication of the crystal parts and the matching dielectric sections is also plagued by fractures.

The technical difficulties encountered here are due to the extremely high dielectric constant of rutile. In this light, crystals with more reasonable dielectric constants seem more and more desirable. In particular, Beryl is a very attractive alternative. Calculations show that Beryl could be used in an 8 mm maser using a magnetic field of 4.5 kilo-gauss and a pump of 56.5 Gc. The gain per unit length as a traveling-wave maser would be much lower than rutile. But this could be made up by using it in a cascaded transmission cavity design.

To our knowledge, Beryl is available commercially only from the Chatham Research Laboratory at a minimum order price of \$5000.

"RADIOASTRONOMY AND UPPER ATMOSPHERE STUDIES IN THE MICROWAVE REGION"

NSF Grant
NSF G-16741

In the previous progress report it was reported than an attempt was being made to employ the 33-foot telescope of the Radioastronomy Laboratory at Hat Creek for observations at 8.35 mm. The project was given up on account of the low gain that the antenna was found to have at this wavelength (an aperture efficiency of about 10 percent). In mid-October the receiver was removed from the 33-foot antenna and returned to the 10-foot antenna. The latter was equipped with a Cassagrain feed system in order to make the operation more flexible, permitting, for example, a rapid replacement of the fixed frequency receiver by the sweeping receiver for the ozone experiments. It was also hoped that the longer effective focal distance would permit greater gain. A substantial increase in gain was not realized although the half-power beamwidth was reduced from 12.0 to 10.3 minutes.

Lunar Eclipse Observations

The receiver was again installed on the 10-foot antenna in time to observe the eclipse of the moon on the morning of December 31. The west coast was particularly favorable as the eclipse began at about 12:30 PST and could be observed throughout its entirety. The experiment was designed to detect any cooling of the central region of the lunar disk during the eclipse. Considering the time of year, observing conditions were fairly good. There was no wind, although there was some haze. Few difficulties were encountered except that during totality the moon could not be seen and some tracking error developed. A preliminary scan of the data shows no large temperature change as expected. A full analysis of the data on the computer is currently underway.

Preparation for Future Work

The new mount for the 10-foot antenna is expected to be installed this Spring. In the meantime experimental work will be continued in Berkeley. The new antenna feed system was designed to accept signals of arbitrary polarization. It is planned to make a study of the polarization of the thermal emission of the moon. Such observations made at longer wavelengths have provided some

information regarding the bulk dielectric properties of the lunar surface materials. Extending this work to these shorter wavelengths should provide further complementary information about the surface. The inferior conjunction of Venus occurs in mid-June this year. It is planned to measure the emission from Venus over the wavelength range of .7 cm to 1.5 cm during the two months surrounding conjunction when the signal-to-noise ratio is favorable. Work on a sweeping radiometer for this observation has been in progress for several months.

Thermal Emission from Jovian NH_3 at Wavelengths near 1 cm

A report describing these calculations has been prepared and will be issued shortly.

"GENERAL SUPPORT GRANT"

"INTERDISCIPLINARY RESEARCH IN THE PHYSICAL,
BIOLOGICAL, ENGINEERING AND SOCIAL SCIENCES"

NASA Grant
NsG 243-62

PHYSICAL AND ENGINEERING SCIENCE PROJECTS

1. Ion Sputtering

The report, "Experimental Investigation of Lithium-Argon Sputtering" by V. Malakhof, R. Stein and H. P. Smith, Jr., will appear as IER AS 63-7. A condensed version of this report will be submitted to the Journal of Applied Physics. No further work in this specific area is planned.

Successful and inexpensive aluminum foil metal vacuum flanges have been built, assembled and tested to pressures of 10^{-7} torr. Pressures of the order of 10^{-8} to 10^{-9} torr are expected following bakeout of the system which should be accomplished during the next few weeks. The target chamber and target-collector assemblies for the cesium-copper sputtering detection by neutron activation analysis have been designed and are now under construction. The same is true for the buffer chamber and energy analyzer.

The problem of detection of copper in the presence of contaminants, primarily sodium, appears to have been solved by using very pure polyethylene and counting the five minute isotope of copper. A second technique of using an activated target appears to be satisfactory for detection of long lived isotopes.

D. DiMichele and H. Henryson, graduate students in the Department of Nuclear Engineering, have begun construction of apparatus to detect small ion currents using pulse techniques as well as construction of a pulsed ion beam. These studies will find application in the time-of-flight measurements of sputtered particle velocity spectra.

2. Plasma Physics

Mr. R. I. Miller and Dr. E. A. Cooper have continued their investigation of plasma instabilities as a source of ionospheric irregularities. An attempt is being made to solve this problem with more rigor and generality than has

yet been achieved. A summary of the work to date on this problem is now being prepared.

Dr. Cooper and Dr. Palm have completed a review on the 2-stream instability and its application in interplanetary space.

3. Hydromagnetics of the Magnetosphere

Mr. D. P. O'Brien has now computed the conductivity tensor elements of the ionosphere and exosphere from 60 km altitude to 40,000 km altitude for all geomagnetic latitudes. The resulting profiles of Hall, Pederson, and parallel conductivity have been presented for the frequencies 100 cps, 30 cps, 10 cps, 3 cps, 1 cps, 0.3 cps, 0.1 cps, 0.03 cps, 0.01 cps and 0.003 cps. Thus all of the band of frequencies in which geomagnetic micropulsations exist has been treated. The information is being applied to studies of the origin and propagation of micropulsations. Sources will be placed in the ionospheric-exospheric model column and the resulting fields at the surface of the Earth studied.

Cooperation in this endeavor continues between O'Brien, Dr. Ross Lomanitz of the New Mexico Institute of Mines and Technology, Socorro, New Mexico, and Mr. R. G. McPherron.

Mr. R. G. McPherron has concluded a preliminary study of balloon-borne magnetometry and is now commencing a study of the interaction of fields and particles in the origin of some types of geomagnetic disturbance.

4. Lunar Studies

a) Lunar Surface

The work concerned with magnetic disturbances on the Moon are being continued. Preliminary results have been summarized and submitted for publication as a Research Note entitled, "On Observations of Lunar Magnetic Storms" by A. Palm and S. Silver. In a separate report which is now in preparation, further details are being presented on the processes that are most likely to occur in the encounter of the solar wind with the solid sphere of the Moon. In the absence of a lunar ionosphere and an appreciable selenomagnetic field, the phenomena may resemble closely those in the Earth's magnetosheath, the region separating the magnetosphere from interplanetary space. The present studies will yield order of magnitude values for such observables as fluctuations in interplanetary magnetic field, plasma density and velocity due to the perturbations in

the solar wind caused by its streaming past the obstacle, the moon. The information will indicate the necessary range and sensitivities to be built into the plasma sensors and magnetometers on board of future lunar probes.

b) Techniques for Mapping Features of the Moon

Mr. William Gantz has tested several small light sources toward possible inclusion in the albedo to color converter. One small zirconium arc looks quite practical for this scanning application. As soon as funds are available work can begin on a breadboard of this system.

In collaboration with Mr. Robert Strom of the Lunar and Planetary Laboratories in Tucson, a new theory on the nature of the lunar ray material is being evolved. As a result of the recent lunar eclipse some previously unpublished data on the brightness vs. phase angle of the ray material on the moon is being made available. These data, in conjunction with certain simple laboratory experiments, may provide the substantiation needed for publication of the theory.

SOCIAL STUDIES PROGRAM

This program underwent considerable organization and enlargement during the summer and fall of 1963. In this progress report, an attempt will be made to describe this organization as well as provide information about the progress on the individual projects.

The program studies the sociological and economic aspects of research and development behavior, with special emphasis on the management of R and D. The intent is to consider all the major aspects of research and development activities, and to fit individual projects into a general framework of study.

In order to create this broad image of R and D activities, the members of the program have devoted considerable time in their weekly seminar in trying to outline all relevant areas for study, whether or not they would be conducted at this University. In this way they hope eventually to supply policy makers with guides to the types of socio-economic study that should be supported.

At present, the most satisfactory outline seems to be one based on a three-way classification: First, research and development can be studied at one of its many levels, ranging from the project, through the branches, divisions and centers, to the management of headquarters and eventually to the industrial,

national and international environment. Second, at any of these levels, the study may attempt to describe and analyze present or past practices, or it may try to design better practices or supply better understanding of how improvement may occur; thus the research aim may be to describe, or to design. Third, at any level, and with either the intent to describe or design, the research may concentrate on aspects that are peculiar to research and development, or it may attempt to make cross-comparisons with other areas of human endeavor; in other words, the research may be specific to R and D, or comparative. The underlying theme of study throughout is the organization of human behavior to accomplish research and development goals, including the relationship between the organization and its socio-economic environment.

The accompanying figure displays the outline of this program's studies. The projects that have already been initiated are shown in the appropriate blocks, with the names of the principal investigators and a number that refers to the description given below. Naturally, some projects are concerned with more than one of the blocks in the outline; in classifying the projects, therefore, we have used the rule that a project is placed in the highest level of its concern, in design rather than description if there is a design goal, and in comparative rather than specific if its output is a comparison of R and D with other kinds of activities. It will be evident from the descriptions given below that strong emphasis is placed on R and D in the aero-space industry.

The research projects deal largely with generalized problems. It must be realized that their results, however, will have direct application to a number of problems associated with the space program. Much of the work will provide a scientific and technical base for the university-community projects which we now have under development for relating and transferring the results of research in the Space Sciences Laboratory to the problems of the community such as urban and industrial development.

OUTLINE OF STUDIES IN RESEARCH AND DEVELOPMENT

LEVEL	DESCRIPTION	DESIGN-ORIENTED
PROJECT Specific		Churchman-Feigenbaum (1) Flood (2)
Comparative		Churchman (3)
BRANCH DIVISION OR CENTER Specific ---		Churchman-Ratoosh- Kruytbosch (4)
Comparative	Wheeler (5) Swatez (6) Kanter (7)	Stimson (16)
HEADQUARTERS Specific	Conrath (8)	
Comparative		Blankenship-Holloway (9)
INDUSTRY Specific	Brewer (10) Woodfill (11) Winter (13)	Albright (12)
Comparative		Stekler (14)
NATIONAL Specific	Strickland (15) Castro (17)	
Comparative		
INTERNATIONAL Specific	Strickland (15)	
Comparative		

Description of Projects:

1. Inquiring System

Professors Churchman and Feigenbaum are studying the design of an "inquiring system". The work to date has consisted of a careful description of problem-solvers of the Newell-Simon type or the Samuels type. An attempt will be made to generalize on the problem-solver to make it more like an empirical inquiring system. Essentially, this means broadening the scope of questions which the inquirer can pose, and permitting the inquirer to go into greater depth than the classical problem solver can. The basic intent of this study is to determine what aspects of research behavior can be programmed explicitly (say on a computer). We already know that a large part of calculation can be programmed. There is already good reason to suppose that such routine activities as abstracting and translating can be programmed. There is also good reason to suppose that we can far better program information retrieval and informal communication of data. Most scientists doubt that the so-called creative or innovative behavior of research can be even approximately well enough understood to be written down as a series of programmed steps. Nevertheless recent work on the logic of discovery and the study of the history of science does show that we can do far more with the creative process than merely regarding it as a closed mystery. This study will concentrate on the use of prior knowledge, and especially on the use of analogy, in creative research. It is expected that this study will produce a far better understanding of the research process, in order to create better resources for the researcher in terms of information and communication.

2. Communication and Retrieval of Information

Professor Merrill M. Flood, in addition to his continuing service as consultant to research staff members and participation in the weekly seminar discussion of project progress and plans, is conducting two research studies. One task (GROPE) is to develop a flexible self-adaptive search code for numerical analysis, and the other (SASIDS) is to develop and test a stochastic adaptive information dissemination system for distribution of technical abstracts.

Alberto Leon, as Postgraduate Research Engineer, is assisting Professor Flood in the GROPE effort. Various computer programs developed by Prof. Flood and Mr. Leon, in previous work at the University of Michigan, are being

translated for use in Berkeley on the IBM 7090 and for use by remote data link in Santa Monica on the Q32 computer at System Development Corporation. These programs, together with iterative search codes developed by other workers, will eventually be consolidated into one universal program that will select adaptively and sequentially among the several separate iterative codes as each problem calculation progresses.

Leonard Jacobson is assisting Professor Flood in the SASIDS effort, with computer programming and system help by Albert Leon. The SASIDS system has been started on a pilot experimental basis, to gain experience with system and computing problems, and will be developed gradually during the coming quarter as more participants are added. The SASIDS task will be integrated closely with the SDI system, operated by Professor Feldman at Berkeley, and some comparative tests and evaluations are planned eventually when experience with both SDI and SASIDS permits.

3. Text on Research Management

Professor Churchman is preparing a text on research management, in which the attempt is made to compare research with production (manufacturing and distribution). Specifically, the comparison attempts to determine where technology has been developed far enough so that it can be taught and thus personnel can be trained to implement it, and where there is no available technology. This work will also try to compare the existing literature in research management and production management from the viewpoint of technological advances.

4. The Role of the Director of an R and D Organization

Churchman, Ratoosh and Kruytbosch are working on a study of the role of director in both government and industrial organizations. This empirical study attempts to determine the way in which this role is regarded by various types of organizations and will pay special attention to the manner in which the research director tries to balance organizational goals and the specific professional and scientific goals of the researchers. The empirical study will determine how research directors spend their time, how they evaluate projects and assign resources and personnel to them, and how they implement the evaluation criteria. A study will also be concerned with the deficiencies in the role of the Research Director and the ways in which these can be overcome. A rough draft of a questionnaire has already been prepared and plans for interviews will now be formulated.

5. Capital Budgeting Process

The first stage of Professor Wheeler's project is essentially completed. The literature search has been finished except for following up references which were found in other readings. This will be carried on simultaneously with the second and the third stages. A tentative model has been outlined for the processing of capital expenditure proposals. This model is divided into four phases which are labeled 1) initiation, 2) evaluation, 3) appropriation, and 4) realization. The initiation phase starts with the conception of an idea and continues to the point where a formal proposal for a capital expenditure is made to the organization. The evaluation phase starts with the formal proposal and concludes at the point where a final decision is made for the organization. The appropriation phase involves the matching of projects to funds and the assignment of funds to the individual proposals. The realization phase includes the control of the expenditure of the appropriated funds, post completion audits, and other steps taken to control the funds after they have been appropriated and to compare results with the returns anticipated to the original proposals. A written draft of the chapter setting forth the model is partially completed.

Interviews in the second stage of the project are expected to start the second week in January. The first interviews will be conducted at Ames Laboratory because of its convenient location. Other interviews will be planned in the next few months. It is anticipated that after the Ames interviews the model will be revised so that it may be used in more final form in subsequent interviews.

6. Institutional Firms

Gerald Swatez is continuing his research into the institutional processes by which large-scale organizations adapt to the pressures inherent in the management of large-scale scientific research. The empirical locus of his study is the Lawrence Radiation Laboratory of the University of California at Berkeley. During this past quarter he has been interviewing scientists and administrators at the Laboratory.

7. Corporate Goals

Herschel Kanter continues his field work at the System Development Corporation. His interviews center around the research program, its origins and development to its current state. In addition, he has been developing a model of a hierarchical organization made up of departments that pursue partially independent goals.

8. Budgeting Behavior in the N. A. S. A.

David W. Conrath has completed a first rough draft of a potential working paper, which is a preliminary study of the overall budgeting process as it exists in N. A. S. A., and it is based primarily on a series of interviews that have been conducted with various personnel at Ames Research Center. At present it would appear that many non-economic factors determine budget decisions, and that further study will need to be undertaken from the viewpoint of the behavioral scientist rather than that of the economist. With this in mind, it is intended that a close investigation will be made of the formation of the fiscal 1966 budget.

9. Relationship between Headquarters and Centers

Work on this study has entered a new phase with the beginning of field interviews and observation at the Ames Research Center by Professors Blankenship and Holloway. In an effort to round out the broad outlines of NASA organization structure, almost a dozen open-ended interviews were conducted with personnel at the Center during December, and several more are scheduled for the present month. To date these interviews have been with administrative personnel, ranging from Assistant Directors to Bureau Chiefs and a Project Manager. Several of the scheduled interviews are to be with people directly involved in conducting research.

Since most of the contacts between Ames and headquarters are centered in the Office of Advanced Research and Technology following the recent reorganization, a four-day trip to Washington is planned for the end of January in order to interview intensively selected people in this office as well as a few in the Office of Space Science. This will also serve the purpose of orienting us towards the type of work done at the Jet Propulsion Lab since some interviews with key personnel there are planned for this spring. Arrangements for spending some time at one of the space flight centers conducting interviews will also be made during this trip to headquarters.

One of the graduate assistants has just finished the first part of an extensive, historical analysis of the development of NASA as an organization. Based primarily on congressional hearings and documents, this part of the study will eventually provide much of the broader, developmental perspective to the growth of and changes in NASA. The second research assistant is completing a comprehensive survey of the literature in the area of measuring and evaluating

scientific competence, a survey which will soon be presented as a working paper for the Space Sciences Seminar group.

10. Assessment of R and D Output

Professor Dawson Brewer is in the process of completing his study of the relationship between R and D output and 1) the size of firm, and 2) the size and characteristics of the R and D activity within the firm. The study is based on research advances in the field of electronics and data on firms in the electronics industry. The data are from the period 1946-1960. As a measure of the output of the research and development programs of companies, the number of research achievements, classified according to their technological significance, is to be used. A panel of individuals that are knowledgeable in the field of electronics is in the process of evaluating the R and D advances according to their technological significance.

11. Analysis of Decision-making in an Industrial D. O. D. Program

Douglas Woodfill is continuing to examine certain aspects of the military R and D industry -- namely, the form of efficiency to be expected, profits and risk; the type of contract is viewed as a key variable.

12. Measures of Research Output

One important aim of economic studies of research is to determine adequate measures of research output. Once such measures are available the very powerful techniques of input-output analysis and mathematical programming become feasible. These techniques conceivably permit careful analysis of the allocation of manpower and other resources to various research efforts. Norman Albright, under the supervision of Prof. Roy Radner, is attempting to extend the understanding of how to measure output.

13. Research and Development Spending and Corporate Growth

This project of Professor Sidney G. Winter, Jr., is an investigation of the processes by which total spending for research and development is determined in industries where federally financed R and D does not play a dominant role. The basic hypothesis under investigation is that the decision process

determining R and D spending at the level of the individual firm is an "adaptively rational" process of the following type: In the short run, total R and D spending is largely determined by some simple rule of thumb, generally an R and D to sales ratio, but in the long run the rule is adjusted in response to various types of feedback information on the payoff from R and D. During the past three months, work has gone forward on elaborating this view of the decision process and devising new ways to subject it to statistical test. The data under analysis are National Science Foundation - Census Bureau survey returns for large firms in several industries. Preliminary results are quite suggestive of (a) the short run fixity of R and D to sales ratios, and (b) the existence of a relationship between interindustry differences in typical R and D to sales ratios and interindustry differences in the payoff to R and D spending.

14. Performance Study

Professor Herman O. Stekler has completed the first objective study that has been made of the structure and performance of the aerospace industry. He has examined many of the major problems facing both the firms in the industry and the government. Many of these problems arose because there is an absence of competition in the industry and the government has had to seek arrangements which promoted efficiency. His major conclusions are: (1) the industry's performance could have been improved (the absence of a competitive environment was the major contributory factor), and (2) the government has recently sought to introduce institutional arrangements which should improve the industry's performance.

15. Political and Sociological Study - Responses to the Space Age

Donald Strickland is presently revising his essay on the responses of New States to space exploits, and expects to have a revised version ready in a few weeks.

He is in the process of writing up his findings on the responses of domestic political groups in the U. S. space program. This manuscript should be completed in first draft in about a month. Thirdly, he is analyzing the responses to a poll of the membership of the American Physical Society. The results of this poll - which concerns the anticipated political effects of the American and Russian space programs - should be available as a working paper within a few

weeks. He is also planning (1) a study of NASA's conception and publication of its own goals, and (2) a study of the motives and incentives for international cooperation in space sciences.

16. Allocation of Funds to Projects

David H. Stimson has completed the history of the allocation process of a particular sum of federal funds. A description of the environment and historical commitments in which this decision-making process occurred has also been completed. Support of this project has been transferred to the Public Health Service.

17. Effect of R and D Industry on Teaching Profession

Barry Castro has been concerned with both the extent to which actual or potential teachers of science are diverted from the classroom by R and D spending, and the effects of whatever shifts have taken place on the "production" of new scientists. A number of assumptions concerning interrelationships between the markets for teachers of science in different sorts of colleges and universities, and research scientists employed by a variety of research institutions, will be tested. The market models to which these assumptions are related will be evaluated in terms of these tests. A survey of the available data has been undertaken, and a case study procedure for resolving some of the remaining problems will be proposed.

"CONTRIBUTIONS TO SURFACE MAGNETIC FIELDS FROM SOURCES INTERNAL AND EXTERNAL TO THE EARTH"

ONR Contract
Nonr 222(89)

Atmospheric, Ionospheric, Exospheric Physics

Three technical reports have been submitted during the interval reported. These reports, Issues No. 72, 84, and 86, Series No. 4, contain information which reasonably describes our activities in these fields. Our primary interest still rests in determining the relationship between solar plasma temporal fluctuations and geomagnetic disturbance observed at the surface of the Earth.

Solid Planetary Physics

1. Magnetotellurics

The six technical reports, Series 4, Issues No. 76, 79, 80, 81, 84, and 85 indicate the general nature of our work in this category. In general we are concerned with assessing the limitations of the magnetotelluric method as it may be applied to study the interiors of planets.

2. Tellurics

D. P. O'Brien has now formulated the problem of the impedance of an n-layered anisotropic Earth. A few practical problems have been solved with the aid of an associated computer program. O'Brien is studying the polarization ellipses of E and H fields in all layers subsequent to an assumption of the polarization of the downcoming wave.

3. Transient Magnetic Variations

(a) Permeability environment

N. E. Goldstein has completed his field work pertaining to the separation of remanent and induced magnetism of natural buried ferromagnets. Goldstein and R. Phillips have commenced a study of the application of Goldstein's field technique and theoretical analysis to ASW problems.

(b) Conductivity environment

Progress in this direction is indicated in the technical report entitled, "The Rubidium Vapor Magnetometer as a Vector Instrument for Recording Micropulsations" (in press) by R. E. Warren.

"SECULAR CHANGE AND THE ORIGIN OF THE DIPOLE FIELD"

CGS Grant
CGS-1167 (G)

Dr. Joachim Meyer, Assistant to Professor J. Bartels at the Geophysikalisches Institut, Gottingen, Germany, is continuing his literature study on the title subject. Dr. Meyer attended the AGU meeting in Boulder December 26 - 28 to contact other researchers working in this field.

"THE EFFECT OF THE IONOSPHERE ON
ATTENUATION OF 'PEARL' ACTIVITY"

NSF Grant
NSF G P-1775 (IQSY Project)

With the start of the IQSY on January 1, 1964, continuous riometer and telluric current recording commenced at our observatory on the Alexander S. Russell estate near Lafayette, California. The 30 Mc riometer records are good and several absorption events have been noted. These are being correlated with riometer records obtained at several other locations. Some direct correlation between geomagnetic disturbance and ionospheric absorption have been noted, but no clear cut "pearl" activity has been noted to date.

R. G. McPherron has commenced a theoretical study of the origin of "pearls" to complement this experimental studies.

PROPULSION DYNAMICS

Supported by

"DETONATION STUDIES OF MIXTURES OF GASEOUS HYDROGEN AND GASEOUS OXYGEN", NASA Contract NAS 8-2634

"REACTION KINETICS OF ACCELERATING FLAMES", NASA Grant NsG-10-59 (Administered by Institute of Engineering Research)

"DEVELOPMENT AND STABILIZATION OF DETONATION", AFOSR Grant AF-129-64 (Administered by Institute of Engineering Research)

DETONATION STUDIES - NASA Contract NAS 8-2634

Room temperature experiments to determine the detonation characteristics of hydrogen-oxygen mixtures in a 2 ft. diameter by 20 ft. long vessel have been completed. Tests were performed using mixtures with volumetric hydrogen concentrations of 50, 67 and 75 percent, at initial pressures of 0.1, 1.0, 10 and 100 mmHg, with ignition by means of a high explosive comprised essentially of 70 grains of PETN. Results obtained at initial pressures of 100 and 10 mmHg indicated the establishment of a steady-state wave at a distance of 10 - 12 feet from the ignitor, although measured wave velocities were consistently 5 to 10 percent below, while peak pressures were slightly greater than the corresponding classical Chapman-Jouguet conditions. Streak Schlieren records obtained at these pressures yielded wave velocities in agreement with those obtained with ionization probes and pressure transducers and, in addition, provided some information on the structure of the wave front and its reflection from the end of the tube.

At initial pressures of 1.0 mmHg and less, a steady-state wave was not observed. Wave velocities and peak pressures, which at all times were several times greater than their corresponding C-J values, decreased continuously along the length of the vessel. Since, under these conditions, the explosive energy of the PETN exceeds the total chemical energy content of the gaseous mixture, it is most probable that the blast generated by the ignitor dominates the wave propagation process.

Several experiments were also performed at initial pressures of 100 mmHg using a weak spark ignition source. In contrast to the results with PETN, this ignitor produced initially a slow burning flame which accelerated to a nearly constant velocity of approximately 1500 ft/sec. The accelerating flame front generated a shock wave which propagated

ahead of it, reflected from the end of the vessel and underwent multiple interactions with flame, leading eventually to the occurrence of a detonation-like process. Results of these tests are being now subjected to a gasdynamic analysis.

Technical Note No. 5, Series No. 4, Issue No. 77, entitled "Design of Primacord Ignition System", by A. J. Laderman, W. G. Struck, and P. A. Urtiew, which describes the development and the blast characteristics of the PETN ignition source, has been issued during this period.

REACTION KINETICS - NASA Grant NsG-10-59

Extensive measurement of stable detonation velocities have now been completed in Pyrex tubes of 1/4", 1/2" and 1" i. d. for ozone-oxygen, ozone-oxygen-argon, and ozone-oxygen-helium mixtures over a range of initial pressures from 80 to 200 mmHg. Extrapolated diameter-independent measured velocities have been found to be approximately 1.5 percent lower than the theoretical Chapman-Jouguet values based on fully thermally equilibrated products. In order to test the velocity versus inverse diameter extrapolation technique under extreme conditions, further velocity measurements will be made in a 1 mm i. d. precision-bore Pyrex tube.

The implications of these results to the kinetics of high temperature ozone decomposition are now being considered in detail, and a manuscript describing the results of this investigation will be submitted for presentation at the 10th Symposium (International) on Combustion which will be held at Cambridge University in the Fall of 1964.

DEVELOPMENT OF DETONATION - AFOSR Grant AF-129-64

Schlieren observations have been made of the initial flame acceleration in hydrogen-oxygen mixtures using glow coil ignition. They provided a complete time-space description of the events preceeding the flame-shock interaction that were described in the previous quarterly progress report. Two manuscripts describing the results of these investigations have been submitted for presentation at the 10th Symposium (International) on Combustion, namely:

1. "Dynamics of Pressure Wave Generation by an Accelerating Flame", by P. A. Urtiew, A. J. Laderman, and A. K. Oppenheim.
2. "Gasdynamic Effects of Shock-Flame Interactions in an Explosive Gas", by A. J. Laderman, P. A. Urtiew and A. K. Oppenheim.

Construction has been started on a shock tube combustion driver section which will provide independent control of shock strength in further flame-shock interaction studies.

As a crucial step in the development of instrumentation for precise measurement of the high amplitude transient pressures generated during the transition to detonation, an analytical technique has been developed to determine the frequency response of pressure transducers. To facilitate the calculations, the method has been programed for the IBM 7090 digital computer.

At the same time, a piezo-electric bar-type pressure sensor with a rise time of 1μ sec has been developed. On the basis of preliminary tests, it appears that the sensor obviates the difficulties associated with ringing, attaining at the same time performance characteristics comparable to those of commercially available transducers that are currently in use.

Publications

The following manuscripts have been presented for publication:

1. "Pressure Wave Generated in a Fissionable Gas by Neutron Irradiation", by H. P. Smith, Jr., C. W. Busch and A. K. Oppenheim, Physics of Fluids, (in press). (Administered by I. E. R.)
2. "Long Duration Spark Light Source for Streak Schlieren Photography of High Speed Events", by G. J. Hecht, C. T. Lilleston and A. K. Oppenheim, ISA Transactions, (in press). (Administered by I. E. R.)
3. "Vector Polar Method for the Evaluation of Wave Interaction Processes", by A. K. Oppenheim, P. A. Urtiew and A. J. Laderman, submitted to the Polish Academy of Sciences for publication in the Archives of Machine Design. (Administered by I. E. R.)

"DETECTION AND STUDY OF MICROORGANISMS IN THE UPPER ATMOSPHERE"

NASA Grant
NsG 104-61

Evaluation tests for an electrostatic precipitator have been continuing in studies conducted at atmospheric pressures. Difficulties in the testing procedure have necessitated that tests be run at atmospheric pressures rather than proceeding to low pressure altitude simulation as originally planned. These difficulties in procedures are as follows: The length of time required for each set of tests is controlled by the time necessary for preparing large quantities of bacteriological sampling equipment and the time necessary for the incubation of collected microorganisms; the complexity of test procedure leads to frequent mistakes in technique which in turn requires repeated duplication of tests to insure reliability; the present method of recovery of precipitated microorganisms gives little assurance of reliability due to contamination and destruction of viable precipitated microorganisms by the recovery technique.

The test procedure has been changed to overcome some of the difficulties, and other changes are planned for the near future. We are now using two Andersen impactors as comparative samplers, one parallel with the precipitator line, and one after the precipitator to indicate the number of microorganisms which pass through the precipitator without being collected. The Andersen impactor parallel to the precipitator line gives an indication of the number of microorganisms passing through the precipitator. The results from tests with this configuration, based on a limited number of successful tests, indicate that high precipitator efficiency collection rates are possible with low levels of current and voltage. These results are in agreement with theoretical performance equations and have caused a reassessment of the efficiency of sampling desirable from the standpoint of recovery of the collected microorganisms. We are dealing with two efficiencies. The first is the efficiency of collection based on creating an electric field causing charging and subsequent attraction and deposition on the wall of the precipitator. The second is the efficiency of recovery of viable organisms which is determined by the ability of the organisms to withstand ozone, which is created by the charging mechanism, and the ability to remove all precipitated microorganisms from the precipitator wall and deposit them on media which will lead to visible growth.

By varying these two efficiencies, a net efficiency can possibly be obtained which will be adequate for aid sampling purposes. The results obtained from tests employing two Andersen impactors are encouraging. Since a decrease in the necessary current level for adequate precipitation leads to a decrease in ozone production, a greater number of microorganisms remain viable. Tests are being conducted to optimize the net efficiency and thus obtain the necessary collection parameters for a flight sampler.

Results indicate that in dividing the airstream from the aerosol chamber, it is necessary to improve the dependability of both splitting the air flow and maintaining the same microorganism density in each line. The present asymetric connection does not behave in a stable and consistent manner and appears to be extremely sensitive to valve settings on each line. A new symetrical fitting will be installed in the near future.

The method of recovery of precipitated microorganisms now requires washing the precipitator cylinders with warm agar and placing the agar in Petri dishes for incubation. Other techniques have been tried in this period. We have placed warm agar in the cylinders, rolled them until the agar solidifies and incubated the cylinders, but we have found it impossible to maintain separate colonies on the agar due to excess moisture on the agar surface within the cylinders. We have previously washed the tubes with sterile water and passed the water through Millipore field monitors, which were placed on agar surfaces for incubation. This technique was discontinued when it was not certain if all the precipitated microorganisms were being removed. From our recent tests it is possible to suppose that under conditions of high voltage and current levels which were employed at that time, assumed unrecovered viable microorganisms were instead microorganisms rendered non-viable by the effect of high ozone concentrations. The Millipore method will be tried again since it has the advantages of low probability of contamination and high count reliability.

If a suitable recovery technique is developed, a change will be made in the test bacteria. Serratia marcescens is now being injected into the aerosol chamber. The limited range of response of this organism to ozone, media and other factors influencing viability may severely limit the usefulness of our final results. It is felt that a typical profile of bacteria will be found in actual flights, and that such a profile should be used now in evaluation tests

and recovery techniques. Further reason, in the future samples to be injected into the aerosol chamber will be obtained from room dust which should have a wide range of airborne bacteria which one might expect to encounter suspended in natural air masses.

Tests have been completed to ascertain the ozone concentrations corresponding to current, voltage, and polarity of the corona discharge. The ozone determinations was done by causing potassium iodide to react with the ozone producing iodine, which then reacts with sodium thiosulfate removing the iodine which is indicated by starch in solution. Results confirm the available information that ozone concentrations are proportional to current and that it is higher for a positive corona than for a negative corona. The polarity is the voltage on the central electrode with respect to the voltage on the precipitator wall.

A search of the literature has been conducted to determine if a diffusion decay method of air sampling employing aerosol reaction with surfaces might be applied as an alternate sampling technique, or might suggest a new method of air sampling applicable to our field. The method has been used for the sizing of air pollution particles on an experimental bases. The method employs the random motion of micro-particles as they pass between surfaces which will cause decay of the aerosol when particles come in contact with the wall. The sampler can be of very small diameter tubes or a series of stacked flat plates with a small distance separating each plate for air flow. Advantages apparent for our application are that very little disturbance would be encountered by the microorganism in the sampling process, that the sampler could be simple to fabricate and operate, and that recovery and incubation could be more direct. Based on theoretical parameters, at atmospheric pressures and given the average size of a bacterial cell, a sampler of very large proportions having extremely close tolerances in plate spacing would be required for moderate quantities of air flow. The effect of high altitude upon the size of sampler required has not been determined, but study is continuing to see how reduction in air density and temperature would affect the required size of sampler.

It has been concluded that the diffusion decay process described above has a negligible effect upon the precipitator evaluation test apparatus, as our flow rates, and pipe diameters and lengths lead to an extremely low

rate of diffusion decay in passage from the aerosol chamber to the electrostatic precipitator.

The design of a flight sampler has been discontinued for the present, since the difficulties encountered in the evaluation of the electrostatic precipitator have required revision of our previous schedule. When the tests now being conducted have yielded sufficient information, and if the precipitator proves to be a practical collection device, then the design of a flight sampler will be resumed in preparation for a high altitude flight.

"DYNAMIC BEHAVIOR OF POROUS ELECTRODE SYSTEMS"

NASA Grant
NsG150-61

A new phase of this project has been initiated in which effects of changing solid matrix structure upon the course of reaction in porous electrodes is being investigated. Rates of oxidation of porous sintered metal electrodes serving as anodes in experimental cells will be measured. This is to be accomplished by removing, impregnating, and sectioning for microscopic examination, samples of these electrodes after several intervals of electrolysis. In this manner the rate of decrease of metal content, and thus reaction rate, can be determined at various depths into the porous electrode, measured from the surface exposed to bulk electrolyte and facing the counter-electrode. Preliminary calculations have been conducted and at the present time design of the experimental cell and procurement of the electrodes is in progress.

The results of current distribution measurements in stacked metal screen electrodes, completed earlier, have been reported in Series 4, Issue 56, Space Sciences Laboratory. Further difficulties have been encountered in measurements of current distribution in a micro-fissure, single pore cell, and certain design modifications have been undertaken.

"EFFECTS OF VARIED DEGREES OF SENSORY DEPRIVATION ON
BRAIN CHEMISTRY, BRAIN ANATOMY AND BEHAVIOR"

NASA Grant
NsG 154-61

An experiment has been started to test cerebral effects in the rate of different degrees of stimulation or isolation. Sets of male triplets of the Berkeley S₁ strain are being used. One animal chosen at random from each litter is being kept in a complex environment and will have training in various mazes and testing devices. Another animal from each litter is being housed in an isolated cage in a sound-insulated chamber. The remaining animal of each litter is being housed with another animal in a cage in the sound-insulated chamber. There are thus three degrees of experiential complexity. At the end of the 80-day experimental period, brain tissue of the animals will be assayed for activity of acetylcholinesterase, cholinesterase, and certain other enzymes.

" FACILITIES "

NASA Grant
NsG(F)-5

This report covers the period from the first week in September 1963, when the preliminary plans were accepted by Professor Brode, Acting Director of Space Sciences Laboratory, through the middle of January 1964.

Frequent meetings were held with the Executive Architects, the Office of Architects and Engineers and the Space Sciences Laboratory staff to resolve advanced programming details such as areas requiring environmental control, special R. F. shielding, power requirements, telephones, health and safety factors, etc. Bid taking procedure was discussed. The bidding document will include such additive and deductive work units as seem suitable to assure that the award will be close to the structure budget.

Completion of working drawings is scheduled for the third week in February. Inspection of construction will be handled by Executive Architects with the University providing overall high level supervision.

INFRARED PLANETARY OBSERVATORY IN THE STRATOSPHERE

NASA Grant
NsG 255-62

A detailed examination of the bolometer calibration data taken after the first flight of Stratoscope II is currently being made in order to determine the bolometer response function. This information is required to pursue the bolometer development proposed in the request for a new grant, UCBSSL 169. Additionally, the bolometer response function can be used to make a refined reduction of the Stratoscope II flight data. Recently, information from several investigators has indicated wide disagreement on several parameters of the Martian atmosphere, particularly the value of the Martian surface pressure. Since the Stratoscope flight data are applicable to this discussion, a proposal, UCBSSL 177, has been submitted to provide the support required to extend the initial reduction of the flight data.

"PREPARATION OF FLIGHT HARDWARE FOR THE
FIRST INTERPLANETARY MONITOR SATELLITE"

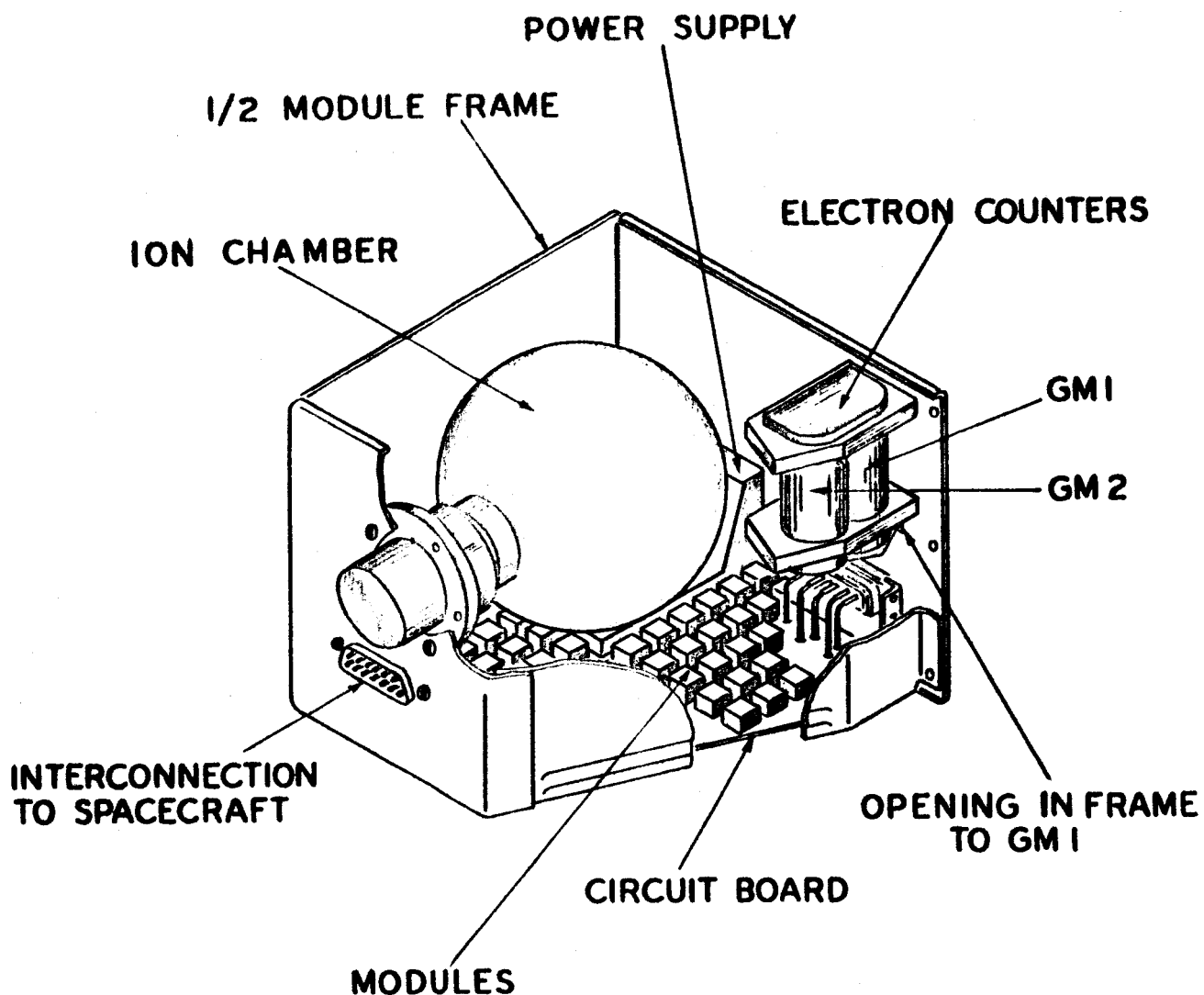
NASA Contract
NAS5-2989

On 26 November 1963 a Delta rocket launched from Cape Canaveral (now Cape Kennedy) placed the Explorer 18 scientific satellite into an orbit that stretches out from the earth a distance equal to half the distance to the moon. This National Space Agency satellite weighs 138 pounds and carries eight scientific experiments. One of the experiment packages on board was prepared at the Berkeley Space Sciences Laboratory and Department of Physics. The California experiment has worked perfectly from launch to the present time and has already given results of outstanding importance to the study of the terrestrial radiation zone or Van Allen belt, as it is often called. This satellite experiment is the first to be initiated and carried out on any campus of the University of California. Its significance to the academic objectives of the University is further emphasized by the fact that a graduate student carried out much of the laboratory work and he is now analyzing the results, partly with the intent of preparing a doctoral dissertation.

The success of this experiment to a large degree reflects the increasing effectiveness of the Space Sciences Laboratory as a source of specialized technical support. The success of the project to date clearly demonstrates that the machine shop, electronic technicians and available test equipment together with faculty scientists and graduate students can undertake the complex tasks involved in space research and will continue to do so. Mr. R. J. Paoli, an electrical engineer, designed the electronic circuits and managed the many important details of subcontracting, environmental testing and liaison.

The data analysis activities are centered at the 2119 University Avenue laboratory and much use is made of the Computer Center facilities in Campbell Hall.

Figure 1 shows the University of California experiment package in a schematic drawing. Figure 2 shows a result obtained from the satellite during a pass through the Van Allen Radiation Zone. One of the most interesting features is the very abrupt decrease in the intensity of trapped radiation at a distance of 70,000 kilometers from the earth's center. The sudden disappearance of the trapped particles is due to the termination of the earth's magnetic field. This results from the pressure exerted by hot solar plasma flowing past the earth.



WEIGHT: 1.78* UNPOTTED, 1.92* POTTED
DIMENSIONS: 4.875" X 4.875" MAX., HEIGHT 3.938"

FIGURE 1

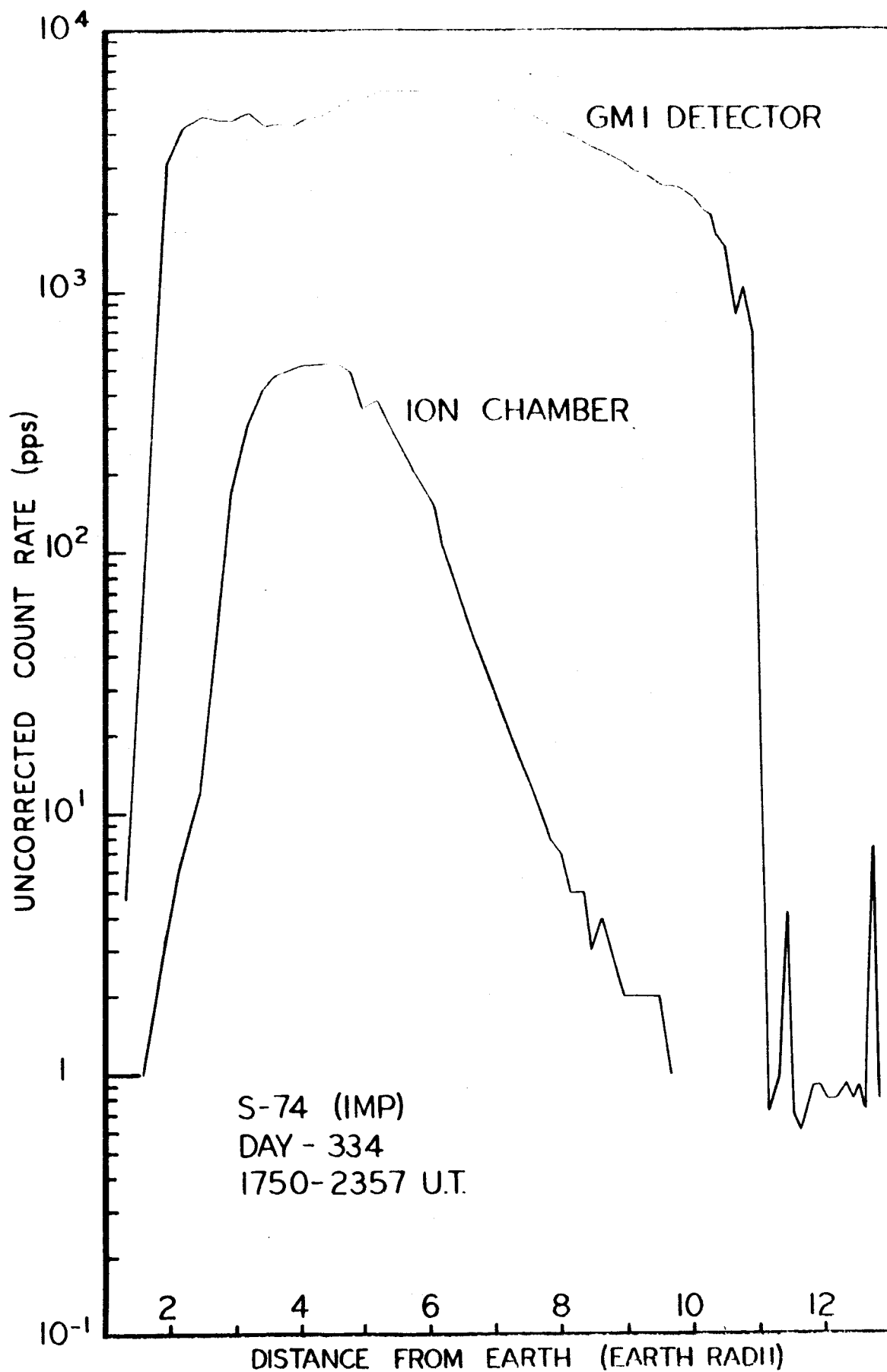


FIGURE 2

**"PREPARATION OF FLIGHT HARDWARE FOR THE
FIRST ORBITING GEOPHYSICAL OBSERVATORY"**

NASA Contract
NAS 5-2222

Integration and testing of the University of California and other experiments into the spacecraft is continuing at the Space Technology Laboratories. The launch date of this 1500 pound satellite will be sometime during this year.

"ELECTRON PRECIPITATION INTO THE AURORAL ZONE"

NSF Grant
NSF GP-2252

The purpose of this new grant is to support development of new experimental apparatus to be flown on high-altitude balloons in 1964 as part of the International Quiet Sun Year program. The purpose of the experiment is to obtain further information on the precipitation of high energy particles into the Earth's atmosphere in the auroral zone. These particles were members of the population of particles in the Van Allen Radiation Zone until some dynamic process caused them to be dumped down the Earth's magnetic field lines into the atmosphere. The primary scientific purpose of the investigation is the understanding of the origin of the Earth's Radiation Zone. An important feature of the study is correlation of results with satellites making direct measurements on the particles in the Radiation Zone.

REFLECTION SPECTRA AS A BASIS FOR STUDYING EXTRATERRESTRIAL LIFE

NASA Grant
NsG 101-61

Considerable effort has been expended on the Michelson interferometer on both the hardware and the computer program for deriving the spectra from the interferograms. To make the system more rigid and to decrease vibrations the aluminum base plate has been replaced with one made of steel and the two motors driving the chopper and the carriage have been shock mounted. To minimize thermal effects, the aluminum trihedral mounts have been replaced with invar mounts. A reference interferometer has been installed and will be used to produce monochromatic fringes which in turn will activate the digitizer. Immersed lead sulfide detectors were received to replace the older detectors but had to be returned to the manufacturer because of an error in the fabrication. It is expected the corrected detectors will be back in our hands by the end of January and that the interferometer will be working satisfactory and in the final test stages by the middle of February. The testing which has been done to date has been carried out using a helium-neon CW gas laser operating at 3.39μ . Using this, we have recorded interference showing 95 percent modulation in the output beam for which the two interfering components have each undergone one transmission and one reflection at the beam splitter. The period of the fringes has been measured and reveals no periodic error in the drive mechanism with an amplitude greater than $.05\mu$. There is a "noise" component, possibly due to jerking of the drive, which has an rms amplitude of about $.05\mu$.

The computer program and the analytical scheme have been examined in considerable detail. Our use of an uncompensated interferometer results in interferograms which are not symmetric due to the different phase shifts of different wavelengths. We have concluded from our study that we cannot conveniently use the analytical approach developed for compensated interferometers by Connes and Nozal. Accordingly we will be obliged to compute sine and cosine transforms, square them, add them, and then take the square root. This procedure has certain disadvantages such as nonlinear addition of the signal and the noise for low signal-to-noise ratios less than 5:1 and greater demands on the computer with respect to capacity and time. Future developments may enable us to refine this approach, in particular to decrease the computer time.

Theoretical work has been started on calculating the reflection coefficients and emissivities for rough dielectric surfaces. The assumption is made that the surface roughness is large compared to the wavelength so that the scattering can be regarded as geometric and the effects of diffraction ignored. The experimental data which will be examined using the derived results will be primarily microwave data on the Moon and infrared data being obtained concurrently in our laboratory.

The recording of reflection spectra of rough surfaces in the laboratory has been delayed due to the protracted delivery of a required accessory for our Beckman IR-7. Apparatus is being designed to enable us to make reflection measurements using the infrared laser which we now have.

The analysis of the diameters of Mars, obtained from the photographic plates of Wright exposed in 1924 and 1926, has continued. Micrometer data on the 1924 plates gave a diameter at λ 4400A of $9''.543 \pm .014$ and at λ 7600A of $9''.324 \pm .011$, reduced to a distance of 1 AU. These are somewhat larger than Wright's original data although the difference in diameters between the two colors, $0''.219 \pm 0''.003$, is in good arrangement with his difference. Depending upon the model used to interpret the data, this value places the top of the blue layer at an altitude of approximately 79 km. The new values for the diameter in the blue are in good agreement with Dollfus' values of $9''.44$ (red and blue) obtained in 1958, but the difference which we observe was not observed by him. The microphotometer data were unusable due to experimental errors involved in recording the curves. These measurements will be repeated shortly with the exclusion of these particular perturbations.

The theoretical study on the interior of Mercury is approaching a conclusion. A rigorous derivation of the pressure of the core has been carried out and the distribution of P , ρ , and g has been calculated with the IBM 7090. The analytical machinery for finding the temperature gradient has been worked out in greater detail.

A file has been compiled of the literature relating to the organic chemistry of meteorites and of terrestrial sediments and fossils. The initial objective of the project has been agreed upon: It requires an examination of the organic compounds present in Pre-Cambrian rocks, the aim being to relate these constituents to the biochemistry of the life-forms of that period in the earth's

history (3×10^9 to 0.5×10^9 years ago). Certain sedimentary rocks have been selected for special attention; for example Prof. Preston Cloud of the University of Minnesota has supplied samples of the Gunflint chert (ca 1.8×10^9 years) and of the Soudan carbonaceous iron formation (ca 2.5×10^9 years).

The laboratory facilities necessary for this phase of the work are now about complete and evaluation of the isolation, separation and identification procedures has begun. Gas-liquid, thin-layer and column chromatography provide the basic separation techniques and infrared, ultraviolet and mass spectroscopy the structure determination probes. Attention has also been given to the various methods which can be used for the initial concentration of the ancient organic constituents, the main difficulty being that of contamination by recent organic matter.

"THEORETICAL AND EXPERIMENTAL EVALUATION OF
INELASTIC NEUTRON SCATTERING AND OTHER NEUTRON
INDUCED REACTIONS FOR REMOTE SURFACE ANALYSIS"

NASA Grant
NsG 452

Since much of the work intended for this project was oriented toward the "Surveyor" flights whose payloads will not now include neutron analysis equipment, Prof. Hans Mark and Dr. Waggoner are now in the process of developing a policy toward the flight program. A number of meetings have been held with scientists from Jet Propulsion Laboratory and from NASA headquarters, and a policy for performing several mock-up measurements has been developed.

Work on this project will commence in February 1964 in cooperation with Lawrence Radiation Laboratory, Livermore.

BIOCHEMICAL ACTIVITIES OF TERRESTRIAL MICROORGANISMS IN SIMULATED PLANETARY ENVIRONMENTS

NASA Grant
NsG 126-61

Biochemical and related genetic problems arising from the physical environments of the terrestrial planets have continued to receive our attention. A summary of progress in the areas of investigation underway is reported.

Studies on Environmental Temperatures

The extreme diurnal temperature variation on the Martian surface has served to focus attention upon the problem of microbial survival following repeated freezing and thawing. Survival is dependent upon a complexity of conditions which have not been rigorously controlled in earlier studies. The present investigation attempts to establish this line of investigation on a more quantitative basis essential for the study of the genetic aspects of this problem. Recent experiments have been designed to increase our knowledge of the "initial effect" i. e. , the loss of viability resulting from rapid freezing to dry ice temperatures, in contrast to the "storage effect" of maintaining cells in the frozen state. One objective of this work is to obtain evidence bearing on hyperplasmolysis induced by high osmotic pressure, as compared to an analogous condition observed in cells subjected to freezing and thawing. Hopefully a knowledge of the mechanisms involved in microbial survival of freezing and thawing will provide us with a better understanding of cellular tolerance to low temperatures, and contribute to the evaluation of the probability of biological contamination.

The problem of evolution of genetic stability is a crucial one for the establishment of life as a continuous manifestation rather than a transient phenomenon. Judging from studies on the effect of elevated temperature and ultraviolet radiation on the genetic material responsible for the chloroplasts of algae and higher plants, such environmental factors impose constraints upon the hereditary continuity of the photosynthetic apparatus and other cytoplasmic organelles. Previous work on the lability of the chloroplast to environmental factors left unsettled the question of the stage at which high temperature acted. It was not apparent whether incubation of cells at 34-35°C. prevented

the development of the chloroplast, or its replication. The experimental separation of the developmental phase from the replicative phase has permitted us to localize the temperature effect. Assays of pigment production in cells capable of chloroplast development but not replication provide evidence that at temperatures which result in the production of colorless progeny, the formation of chlorophyll from protochlorophyll is not inhibited. These results are consistent with the view that elevated temperatures act by preventing the replication of chloroplasts and not their development from precursor structures. In this respect, the thermal effect on chloroplasts parallels that of ultraviolet radiation. The results of this study is being prepared for publication.

Studies in Anaerobic Environments

It has been postulated that the turnover of biologically important compounds becomes a serious problem in environments lacking atmospheric oxygen, and that methane and certain aromatic structures would tend to accumulate. Previous studies have established that molecular oxygen is an obligatory oxidant for the enzymatic splitting of the aromatic ring. We have proposed that oxidants generated by photochemical reactions may be of sufficiently positive potential to function in reactions normally requiring the participation of atmospheric oxygen. Recent experiments with photosynthetic bacteria provide evidence for growth under conditions excluding molecular oxygen with benzoic acid as sole carbon source. In these non-sulfur photosynthetic bacteria, carbon dioxide reduction is light-dependent, and coupled to the oxidation of organic substrates. From preliminary experiments on the CO_2 relationships of cells grown with benzoate as substrate, it is clear that growth is possible even in the absence of exogenous CO_2 . When exogenous CO_2 is supplied, it has a very stimulatory effect on growth; and there may be a requirement for at least traces of CO_2 to initiate growth. Other experiments in progress should provide additional information on this question.

University of California Lectures on Horizons in Space Biosciences: Exobiology

At the request of the University of California Extension Division and with the encouragement of the Director of Space Sciences Laboratories, we have organized a statewide series of lectures entitled: Horizons in Space Biosciences: Exobiology. The course is to be offered during the spring semester

of 1964 for university credit and is intended for scientists, engineers and students who are interested in or concerned with space sciences, technology, or the fundamental biological problems in the exploration of the planets. A brief description of the course is appended.

"Horizons in Space Biosciences: Exobiology"

The development of spacecraft capable of carrying instruments and men beyond the earth creates an urgent need for mutual understanding between biological scientists and engineers. Their close cooperation will be essential in the design and execution of a meaningful experimental program, to investigate the moon and planets for evidence of indigenous life, and to prevent needless destruction of scientific information during the course of space exploration. The present series of lectures was organized to provide the physical and biological background necessary for an understanding of the major problems of exobiology, to consider the immediate and long-range goals in the study of extraterrestrial life, and to serve as a guide to the present and future technological requirements for such research. The lectures are largely concerned with the nearby planets as early targets for the investigation of indigenous life. The environmental conditions required for the production of organic matter and the evolutionary processes involved in the origin of life on earth will be discussed to provide a basis for approaching the problems of life-detection on other planets.

"CONTROL AND INFORMATION SYSTEMS"

NASA Grant
NsG 354

Optimal Control of Discrete Time System (B. W. Jordan, Prof. E. Polak)

A report entitled as above is being prepared and will be submitted for publication as two separate papers.

The problem considered in this report is that of finding the optimal controls for a class of synchronous or asynchronous, fixed duration processes in nonlinear, discrete time systems. First the necessary conditions which an optimal control must satisfy are derived then an algorithm is developed for finding the optimal control in specific problems.

The necessary conditions which an optimal control must satisfy are related to Pontryagin's Maximum Principle for continuous time problems and the techniques used in the proof are quite similar.

The algorithm developed is one of steepest descent in the space of the control variables.

For samples data control systems, the necessary conditions and the algorithm may be used not only to find the optimal control sequence, but also the optimal sampling instants, assuming that the total number of these in a given process cannot exceed a fixed integer.

Fuel and Energy Optimal Control of Discrete Linear Systems Using Analog Electrical Networks (M. D. Canon, Prof. E. Polak)

A report entitled as above has been written and will be submitted for publication in a shortened version. The problem it deals with is the following:

Given a linear time-invariant sample data system governed by the state transition equation

$$\underline{x}_{k+1} = A \underline{x}_k + \underline{b} u_{k+1} \quad |u_k| \leq 1 \quad k = 0, 1, 2, \dots$$

and given a fixed number of sampling periods N . Find a control sequence which transfers the initial state of the system to a desired terminal state,

in N sampling periods, minimizing a cost

$$J = \sum_{i=1}^N f_i(u_i)$$

It is shown that electrical analog circuits exist which solve a class of control problems of this form. In particular, a solution to the minimum fuel and minimum energy problems is obtained. The analog networks are developed by application of two network theorems proved in this paper. One method of implementing the circuits is presented; preliminary experimental results are included.

Equivalence Transformations for Optimal Control Problems (C. Cullum,
Prof. E. Polak)

An investigation of a class of optimal control problems with integral performance criteria and specified terminal conditions is made from the standpoint of determining if some of the problems may be said to be "equivalent". An optimal control problem is assumed to consist of the following objects:

- 1) A system equation (assumed to be a differential equation in this work).
- 2) A state space and a control space.
- 3) A path integral cost function which is to be minimized.
- 4) A given set of possible terminal states.
- 5) Specified restrictions on the control variables.

The investigation is based on nonsingular transformations from the state space of one system to the state space of another system. Such a transformation is defined to be an equivalence transformation if the optimal control functions for initial states in the two systems which are image points under the transformation are related in some well-defined way so that one control function may be computed from the knowledge of the other and the transformation.

If necessary and sufficient conditions can be obtained which determine if a transformation is an equivalence transformation without prior knowledge of the optimal control functions for the two problems, then the existence of such a transformation will permit the determination of the optimal control function for one system whenever the optimal control functions for the other system are known.

To date certain necessary conditions and certain sufficient conditions have been obtained which may be used to test a transformation for the equivalence property. Simple examples of problems solved through the use of equivalence transformations have been worked out. Work is proceeding in the area of determining more satisfactory tests for equivalence and in the construction of more complex examples of the application of these transformations.

Study of Non-linear Systems (L. Hasdorf, Prof. C. A. Desoer)

Completion of a thesis on this portion of the grant awaits the computation of two examples.

An On Line Solution to Sampled Data Time Optimal Control (D. P. McCown, Prof. J. H. Eaton)

The problem considered is that of designing a special purpose computer that is rapid enough to provide an on-line solution to the sampled-data time optimal control problem in which the inputs are subjected to amplitude constraints.

The computer is used to simulate a differential equation whose steady state solution yields the input sequence that will take the sampled system from a given initial state to the reachable (in a given number of sampling periods) state closest to a specified terminal state. The time optimal control problem is solved by increasing the number of sampling periods until the specified terminal state is reachable. A paper entitled as above was published in the Journal of Electronics and Control, Vol. SV, No. 4, pp. 333-341.

At present, a computer capable of solving the optimal control problem for fourth order systems is nearing completion. Once it is operative, it will be used in experiments involving the effect of noise on such a system.

Interconnection of Systems (Dan Chezan, Prof. C. A. Desoer)

The problem under consideration consists of understanding better the idea of interconnection of systems. There are a great many problems in connection with this which may be considered, but only a few partial answers have so far been obtained. The following are examples:

1. When does it "make sense" to talk about interconnection of systems belonging to a particular class? When will the interconnection belong to the same class as the component systems? Some results relating to

these questions were obtained by C. Zames ("Realizability Conditions for Nonlinear Feedback Systems", Trans. PGCT, 1961) and I. W. Sandberg ("Signal Distortion in Nonlinear Feedback Systems", Bell System Technical Journal, November 1963).

2. When is the converse possible (even approximately), that is, given a system (i. e. , a mathematical model), is it possible to decompose it into simpler components? The discrete finite state case is fairly simple and has been studied by Hartmanis ("On the State Assignment Problem for Sequential Machines", IRE Trans. on Computers, 1961, p. 157). However, in the continuous case the problem is far more complex.
3. Finally, what can be deduced about the optimal control of the composite system judging from the behavior of its components.

It is expected to obtain a classification of systems which will yield more information about the nature of their behavior, in the context of the above questions.

The Analysis and Synthesis of Probability Transformers (Donovan L. Moorehead,
Prof. E. Wong)

A report entitled as above is being prepared.

The purpose of this project was to investigate the effect of finite state machines on an input random process, and to propose a method whereby a machine can be designed that transforms the probability measure of a process into a specified measure.

Of particular interest is what a finite automation does to certain important properties that random processes can have. It is shown that all finite state machines can preserve the stationarity of input processes via specifying an appropriate initial probability distribution over the states of the machine.

Necessary and sufficient conditions are obtained on the structure of a finite state machine such that the process consisting of the sequence of states will be ergodic. This is achieved by extension of a theorem in information theory on similar conditions for finite state channels.

A topic given considerable attention is the synthesis of a finite state machine whose output will be a random process with a specified finite order probability distribution, given a particular input process and its associated

measure. It can be shown that this problem cannot be solved exactly, but that an arbitrarily close approximation can be achieved subject to an error criterion defined in the thesis. A class of processes the measure of which can be realized exactly is also given.

Necessary and sufficient conditions are given on a machine such that the output process be a finite Markov chain. There are also certain equivalences between Markov chains and finite state machines demonstrated to add to the host of similarities that have already been established.

This work was supported by NASA only in part.

Decomposition of Large Scale Systems (P. P. Varaina, Prof. L. A. Zadeh)

Many large systems are made up of small sub systems "weakly" coupled together. It seems reasonable to suppose that the solution of these large systems could be simplified by making use of this structural property.

In the case of Mathematical Programming, various methods have been developed along these lines, by Dantzig and Wolf, Rosen, and others. At present, we are trying to extend the method of Dantzig to the case where the off-diagonal blocks are not zero but have a single value, by determining the conditions under which the optimal basis does not change if the off-diagonal terms are equated to zero.

"SPACE BIOPHYSICS"

NASA Grant
NsG 139-61

"SPACE PHYSIOLOGY"

NASA Contract
NAS 2-1357

The single unit blood pressure transducer-transmitter is being modified to increase the stability of its circuits and to improve its capability in measuring pressures. Mechanical motion of the transducer diaphragm will be severely limited. This makes possible a very close approximation to true pressure measurement and will decrease errors caused by changes in the arterial wall. This change in the transducer will make it necessary to increase the sensitivity of the sensing element.

Several test circuits have been built, two of which have been incorporated in units which are now undergoing tests for the efficiency of the present potting and construction techniques. A third circuit, designed by Mr. Jenkinson, has been built and is being tested. Results show that this circuit is capable of providing a stable oscillator, independent of temperature, provided that the coils do not change in inductance as a result of temperature changes.

Tests show that some temperature sensitivity lies in the transducer and transmitter coils. Some work has been started towards possible elimination of the transmitting coil and modification of the transducer coil to eliminate the temperature sensitivity of this component. Transducer-transmitter circuits of continuously transmitting types and blocking types were studied. Various characteristics were observed among the many types of oscillators investigated.

Transmitters have been developed which are capable of transmitting three different types of data simultaneously with very low power. A series of measurements was made in a 65,000 gallon salt water tank to test the effectiveness of low level signals through salt water. The feasibility of telemetering from diving mammals and from fishes was demonstrated. The transmitted signals could be received at distances up to 50 feet. These measurements also further elucidated the manner in which signals are transmitted through an animal's tissues. Associated with this work was the investigation of a new type of transmitting antenna which consists of an insulated dipole with conducting end electrodes. This proved considerably more efficient than the

loop (magnetic dipole) antenna which has previously been almost universally used.

In collaboration with a group at Oak Knoll, swallowable pressure transducers were used to study the peristaltic patterns in human beings. Mr. Harvey Fishman has succeeded in detecting the magnetic field induced as an impulse and propagated along a nerve bundle. By using a calibrated amplification system, he was able to make the first estimation of the magnitude of this field. It was found to be several hundred microgauss. Two review articles on the subject of telemetry have been prepared.

"CHEMISTRY OF LIVING SYSTEMS"

NASA Grant
NsG 479

Studies with RNA Polymerase

The past three months have been largely spent in getting together equipment, glassware, and supplies for studies with RNA polymerase. Preparations of the enzyme have been made from Azotobacter vinelandii. Preparations of cell nuclei have also been made for studies of the primer function of DNA. An outline for proposed work is currently being written in connection with a supplementary grant to be requested from the National Institutes of Health.

RNA Sequence Studies

RNA is being prepared and purified from tobacco mosaic virus for use in sequence studies and the accumulation of RNA from this procedure is going satisfactorily. Fractionation of RNA coupled with a "marker" molecule is being carried out by column chromatography. A site visit was made on January 4, 1964, by representatives of the National Institutes of Health Committee on biochemistry grants.

Enzyme Content of Polysomes

Polysomes from E. coli formed in vivo with natural mRNA have a high protein to RNA ratio and a high relative concentration of certain enzymes (Proceedings of the National Academy of Sciences, in press). Most striking is a group of nucleoside triphosphatases, whose activity per mg protein of polysomes is ten times higher than that of single ribosomes, and one hundred times higher than that of the soluble proteins.

Other enzymes, such as pyrophosphatase and phosphodiesterase do not show this preferential absorption. Polysomes are, however, saturated with the enzymes needed for amino acid incorporation (AAI). Addition of the usual amounts of supernatant protein caused the AAI to be inhibited by as much as 80 percent. Smaller amounts caused less inhibition, but no stimulation was ever observed. sRNA produced a variable stimulation, ranging from tenfold for fresh polysomes to but 30 percent for liquid N stored ones. At the same time the total activity decreased from 1 $\mu\text{mole C}^{14}$ AA per mg protein to 0.1 μmole , the residual AAI

being quite stable. The system is still absolutely dependent on a XTP regenerating source, but only partially on added XTPs. AAI with polysome-enzyme complexes is much more resistant to inhibition by puromycin and chloramphenicol than AAI with an unfractionated system.

"FLUID MECHANICS, THERMODYNAMICS AND HEAT TRANSFER"

NSF Grant
NSF GP-2103

During the period October 1 to December 31, 1963, work under this grant was concentrated in three areas: Turbulent shear flows, aerodynamics of vibrating cylinders, and visualization of rarefied gas flows. The work was carried out by five graduate students working as Research Assistants under the supervision of Professors G. M. Corcos, M. Holt and F. C. Hurlbut.

In turbulence, two related theoretical investigations are in progress. The first concerns the stability of boundary layer turbulence when it is subjected to disturbing influences. It is hoped to change the steady state in the boundary layer by transferring turbulent energy from a low to a high wave number range. The second investigation is concerned with an examination of the validity of the linear model of the inner part of the turbulent boundary layer.

Calculations are in progress to improve the formula for the pressure coefficient on distorted cylinders in supersonic streams. Present theories only take account of fixed shapes and these are being extended to include unsteady effects of low or moderate frequency.

Finally, support has been given in the current quarter to the development in part of the sodium seeding and optical systems of a sodium resonance scattering apparatus for rarefied gas flow visualization. It is anticipated that the device will contribute materially to the success of a proposed film on rarefied gas dynamics.